

## Adjustable Micropower Voltage References

### General Description

The LM185/LM285/LM385 are micropower 3-terminal adjustable band-gap voltage reference diodes. Operating from 1.24 to 5.3V and over a 10 $\mu$ A to 20mA current range, they feature exceptionally low dynamic impedance and good temperature stability. On-chip trimming is used to provide tight voltage tolerance. Since the LM185 band-gap reference uses only transistors and resistors, low noise and good long-term stability result.

Careful design of the LM185 has made the device tolerant of capacitive loading, making it easy to use in almost any reference application. The wide dynamic operating range allows its use with widely varying supplies with excellent regulation.

The extremely low power drain of the LM185 makes it useful for micropower circuitry. This voltage reference can be used to make portable meters, regulators or general purpose

analog circuitry with battery life approaching shelf life. Further, the wide operating current allows it to replace older references with a tighter tolerance part.

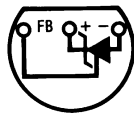
The LM185 is rated for operation over a  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  temperature range, while the LM285 is rated  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  and the LM385  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The LM185 is available in a hermetic TO-46 package and a leadless chip carrier package, while the LM285/LM385 are available in a low-cost TO-92 molded package, as well as S.O.

### Features

- Adjustable from 1.24V to 5.30V
- Operating current of 10 $\mu$ A to 20mA
- 1% and 2% initial tolerance
- 1 $\Omega$  dynamic impedance
- Low temperature coefficient

### Connection Diagrams

TO-92  
Plastic Package

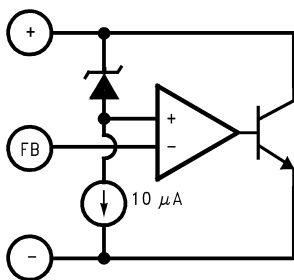


00525009  
Bottom View

## Ordering Information

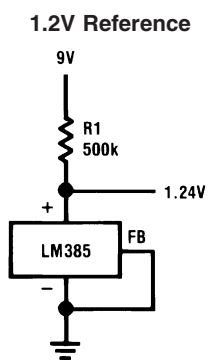
|       |          |          |      |
|-------|----------|----------|------|
| TO-92 | LM285BXZ | LM385BXZ | Z03A |
|       | LM285BYZ | LM385BYZ |      |
|       | LM285Z   | LM385BZ  |      |

## Block Diagram

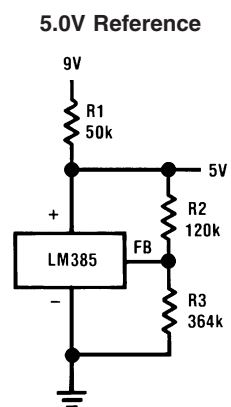


00525013

## Typical Applications



00525014



00525002

$$V_{OUT} = 1.24 \left( \frac{R3}{R2} + 1 \right)$$

### Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

|                         |                |
|-------------------------|----------------|
| Storage Temperature     | -55°C to 150°C |
| Soldering Information   |                |
| TO-92 Package (10 sec.) | 260°C          |

(Note 2)

|                 |      |
|-----------------|------|
| Reverse Current | 30mA |
| Forward Current | 10mA |

Operating Temperature Range (Note 3)

|              |                |
|--------------|----------------|
| LM185 Series | -55°C to 125°C |
| LM285 Series | -40°C to 85°C  |
| LM385 Series | 0°C to 70°C    |

See An-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

### Electrical Characteristics (Note 4)

| Parameter                                    | Conditions   | LM185, LM285 |                                |                                |                                |                                | LM385     |                                |                                |                                |                                | Units<br>(Limit)             |
|--|--|--------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|-----------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|------------------------------|
|  |  | Typ          | LM185BX,<br>LM185BY            |                                | LM285                          |                                | Typ       | LM385BX,<br>LM385BY            |                                | LM385                          |                                |                              |
|  |  |              | Tested<br>Limit<br>(Note<br>5) | Design<br>Limit<br>(Note<br>6) | Tested<br>Limit<br>(Note<br>5) | Design<br>Limit<br>(Note<br>6) |           | Tested<br>Limit<br>(Note<br>5) | Design<br>Limit<br>(Note<br>6) | Tested<br>Limit<br>(Note<br>5) | Design<br>Limit<br>(Note<br>6) |                              |
| Reference Voltage                            | $I_R = 100\mu A$   | 1.240        | 1.252                          |                                | 1.265                          | <b>1.270</b>                   | 1.240     | 1.252                          | <b>1.255</b>                   | 1.265                          | <b>1.270</b>                   | V<br><br>(max)<br>V<br>(min) |
| Reference Voltage Change with Current        | $I_{MIN} < I_R < 1mA$<br>$1mA < I_R < 20mA$  | 0.2<br>4     | 1<br>10                        | <b>1.5</b><br><b>20</b>        | 1<br>10                        | <b>1.5</b><br><b>20</b>        | 0.2<br>5  | 1<br>15                        | <b>1.5</b><br><b>25</b>        | 1<br>15                        | <b>1.5</b><br><b>25</b>        | mV<br>(max)                  |
| Dynamic Output Impedance                     | $I_R = 100\mu A, f = 100Hz$<br>$I_{AC} = 0.1 I_R, V_{OUT} = V_{REF}$<br>$V_{OUT} = 5.3V$ | 0.3<br>0.7   |                                |                                |                                |                                | 0.4<br>1  |                                |                                |                                |                                | $\Omega$                     |
| Reference Voltage Change with Output Voltage | $I_R = 100\mu A$   | 1            | 3                              | <b>6</b>                       | 3                              | <b>6</b>                       | 2         | 5                              | <b>10</b>                      | 5                              | <b>10</b>                      | mV<br>(max)                  |
| Feedback Current                             |  | 13           | 20                             | <b>25</b>                      | 20                             | <b>25</b>                      | 16        | 30                             | <b>35</b>                      | 30                             | <b>35</b>                      | nA<br>(max)                  |
| Minimum Operating Current (see curve)        | $V_{OUT} = V_{REF}$<br>$V_{OUT} = 5.3V$  | 6<br>30      | 9<br>45                        | <b>10</b><br><b>50</b>         | 9<br>45                        | <b>10</b><br><b>50</b>         | 7<br>35   | 11<br>55                       | <b>13</b><br><b>60</b>         | 11<br>55                       | <b>13</b><br><b>60</b>         | $\mu A$<br>(max)             |
| Output Wideband Noise                        | $I_R = 100\mu A, 10Hz < f < 10kHz$<br>$V_{OUT} = V_{REF}$<br>$V_{OUT} = 5.3V$            | 50<br>170    |                                |                                |                                |                                | 50<br>170 |                                |                                |                                |                                | $\mu V_{rms}$                |

### Electrical Characteristics (Note 4) (Continued)

| Parameter   | Conditions   | LM185, LM285 |   |                                |                                | LM385                          |     |                                |                                | Units<br>(Limit) |                                |                                |
|---|--|--------------|---|--------------------------------|--------------------------------|--------------------------------|-----|--------------------------------|--------------------------------|------------------|--------------------------------|--------------------------------|
|   |  | Typ          | LM185BX,<br>LM185BY<br>LM185B,<br>LM285BX,<br>LM285BY |                                | LM285                          |                                | Typ | LM385BX,<br>LM385BY            |                                |                  | LM385                          |                                |
|   |  |              | Tested<br>Limit<br>(Note<br>5)                        | Design<br>Limit<br>(Note<br>6) | Tested<br>Limit<br>(Note<br>5) | Design<br>Limit<br>(Note<br>6) |     | Tested<br>Limit<br>(Note<br>5) | Design<br>Limit<br>(Note<br>6) |                  | Tested<br>Limit<br>(Note<br>5) | Design<br>Limit<br>(Note<br>6) |
| Average<br>Temperature<br>Coefficient<br>(Note 7) | $I_R = 100\mu A$ X Suffix  |              | 30  |                                |                                |                                |     | 30                             |                                |                  |                                | ppm/°C                         |
|   | Y Suffix   |              | 50  |                                |                                |                                |     | 50                             |                                |                  |                                | (max)                          |
|   | All Others   |              |   | 150                            |                                | 150                            |     |                                | 150                            |                  | 150                            |                                |
| Long Term<br>Stability                            | $I_R = 100\mu A$ , T = 1000<br>Hr,<br>$T_A = 25^\circ C \pm 0.1^\circ C$ | 20           |   |                                |                                |                                |     | 20                             |                                |                  |                                | ppm                            |

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed.

**Note 2:** Refer to RETS185H for military specifications.

**Note 3:** For elevated temperature operation,  $T_{Jmax}$  is:

|       |       |
|-------|-------|
| LM185 | 150°C |
| LM285 | 125°C |
| LM385 | 100°C |

| Thermal Resistance                  | TO-92  | TO-46   | SO-8    |
|-------------------------------------|--|---------|---------|
| $\theta_{JA}$ (Junction to Ambient) | 180°C/W (0.4" leads)<br>170°C/W (0.125" leads) | 440°C/W | 165°C/W |
| $\theta_{JC}$ (Junction to Case)    | N/A  | 80°C/W  | N/A     |

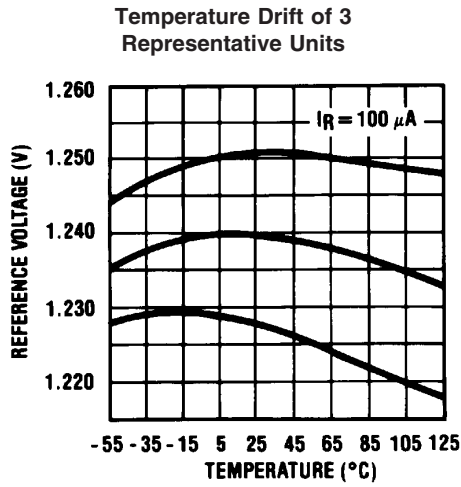
**Note 4:** Parameters identified with **boldface type** apply at temperature extremes. All other numbers apply at  $T_A = T_J = 25^\circ C$ . Unless otherwise specified, all parameters apply for  $V_{REF} < V_{OUT} < 5.3V$ .

**Note 5:** Guaranteed and 100% production tested.

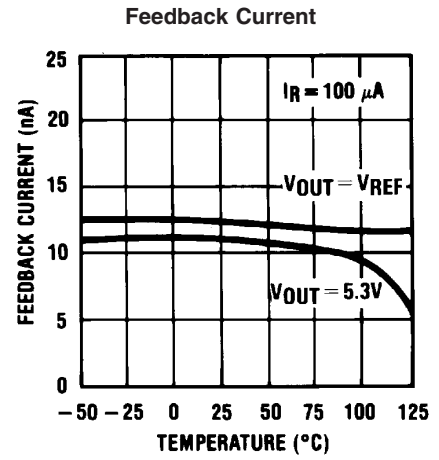
**Note 6:** Guaranteed, but not 100% production tested. These limits are not to be used to calculate average outgoing quality levels.

**Note 7:** The average temperature coefficient is defined as the maximum deviation of reference voltage at all measured temperatures from  $T_{MIN}$  to  $T_{MAX}$ , divided by  $T_{MAX} - T_{MIN}$ . The measured temperatures are -55, -40, 0, 25, 70, 85, 125°C.

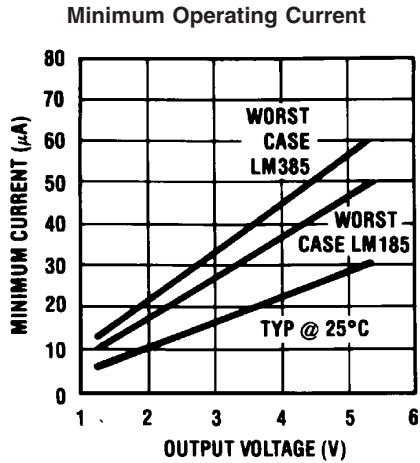
## Typical Performance Characteristics



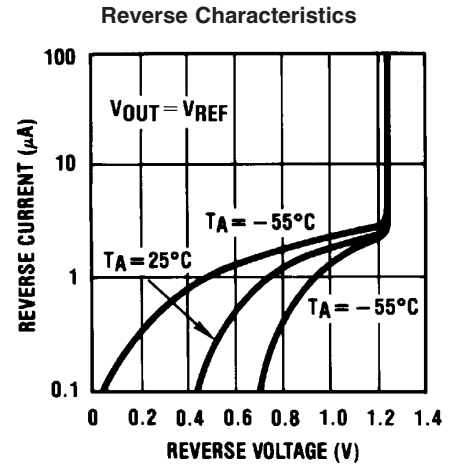
00525016



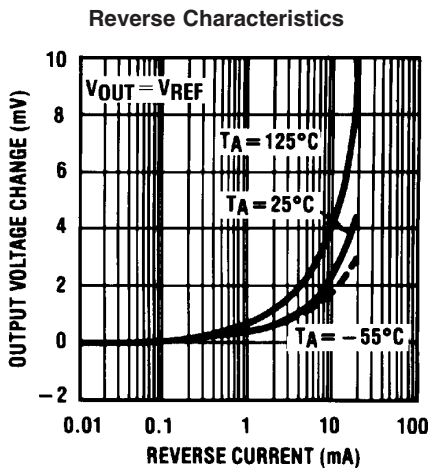
00525017



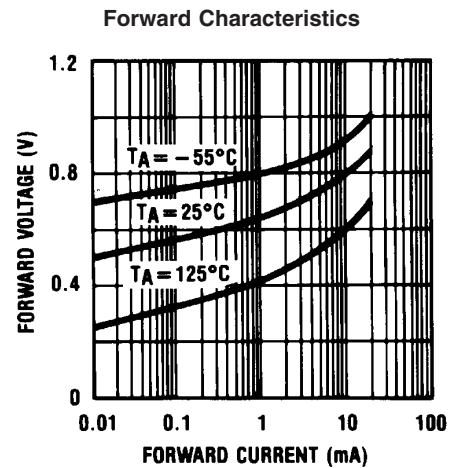
00525018



00525019



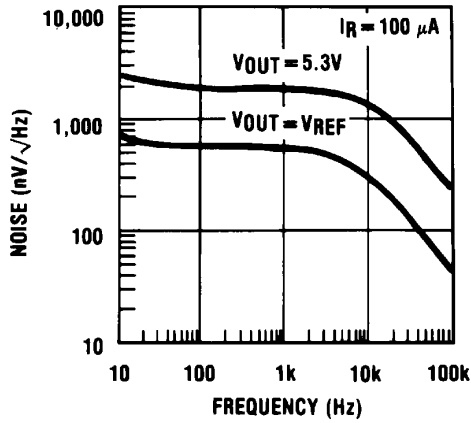
00525020



00525021

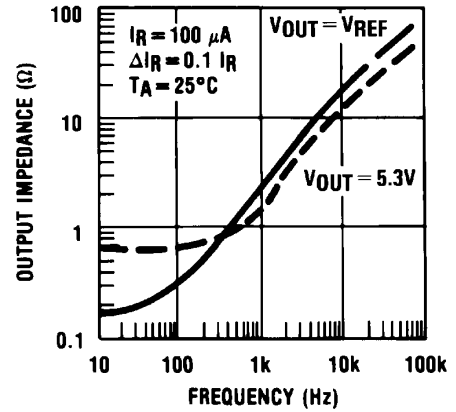
Typical Performance Characteristics (Continued)

Output Noise Voltage



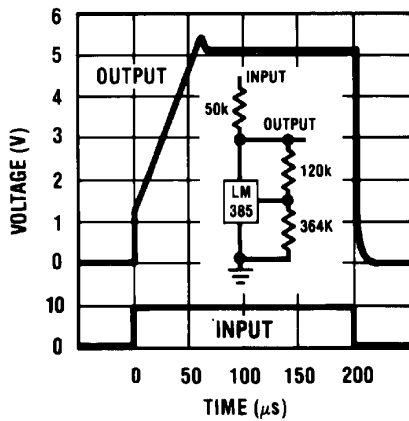
00525022

Dynamic Output Impedance



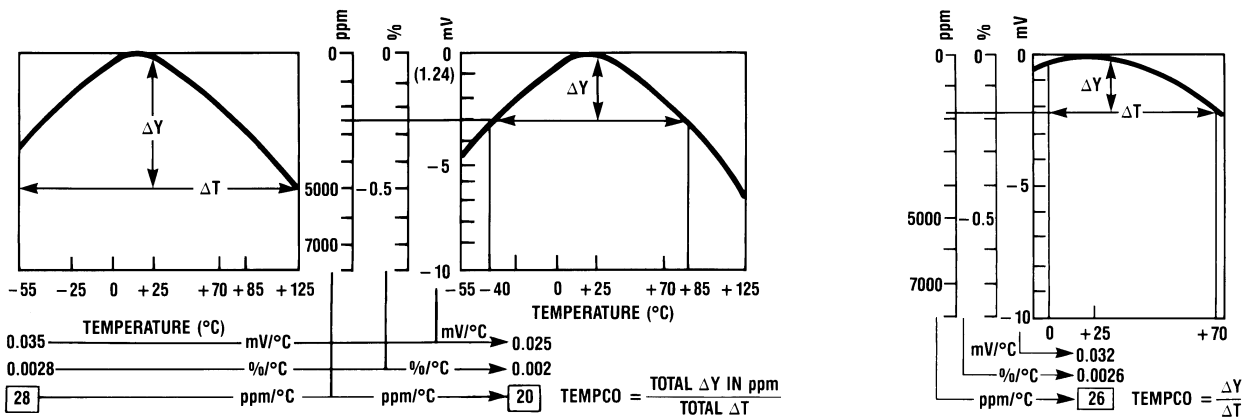
00525023

Response Time



00525024

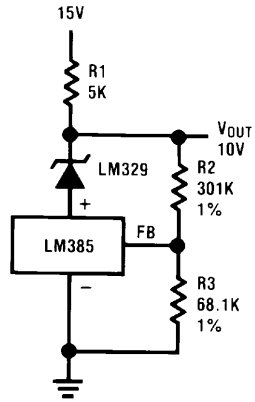
Temperature Coefficient Typical  
LM185 LM285 LM385



00525004

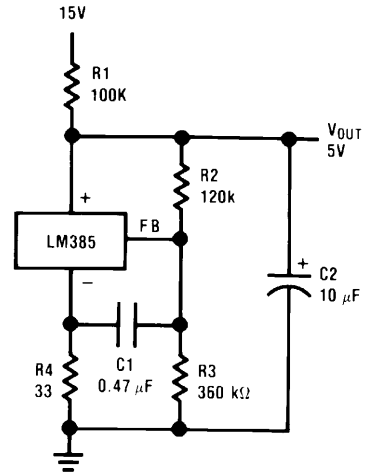
## Typical Applications

Precision 10V Reference



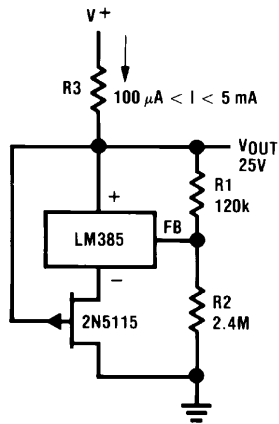
00525025

Low AC Noise Reference



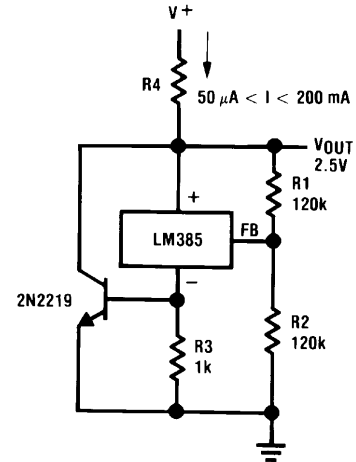
00525026

25V Low Current Shunt Regulator



00525027

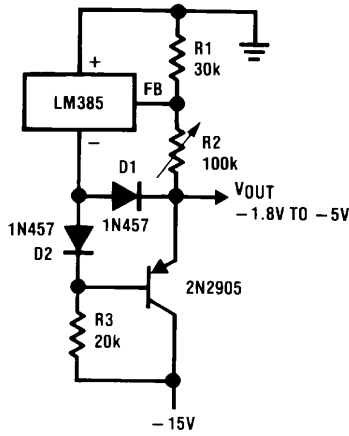
200 mA Shunt Regulator



00525028

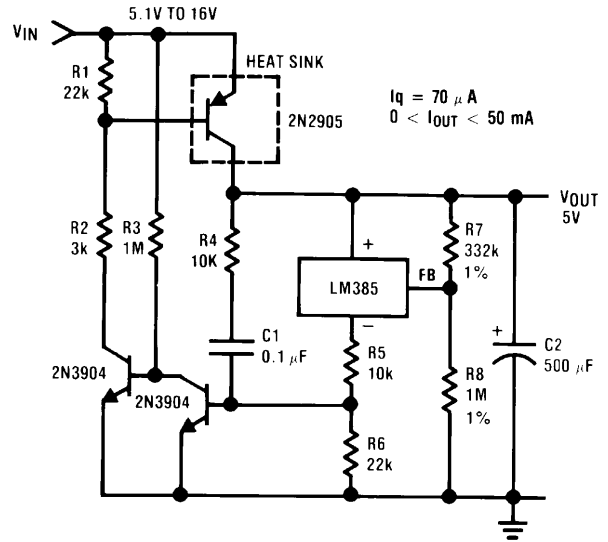
Typical Applications (Continued)

Series-Shunt 20 mA Regulator



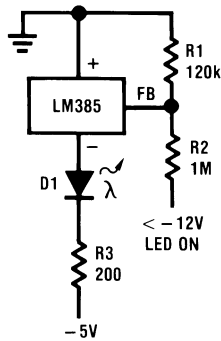
00525029

High Efficiency Low Power Regulator



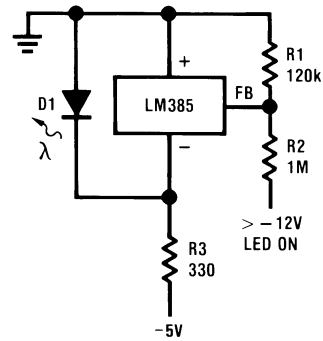
00525030

Voltage Level Detector



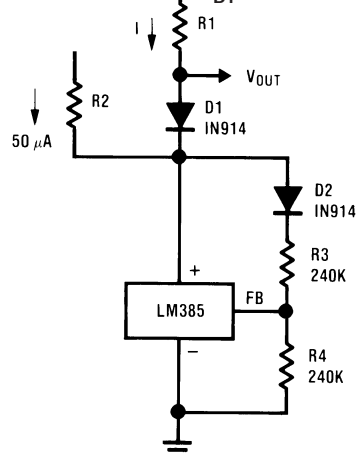
00525031

Voltage Level Detector



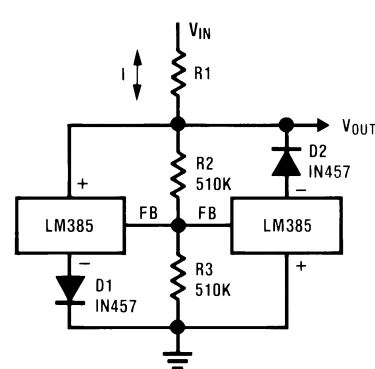
00525032

Fast Positive Clamp



00525033

Bidirectional Clamp

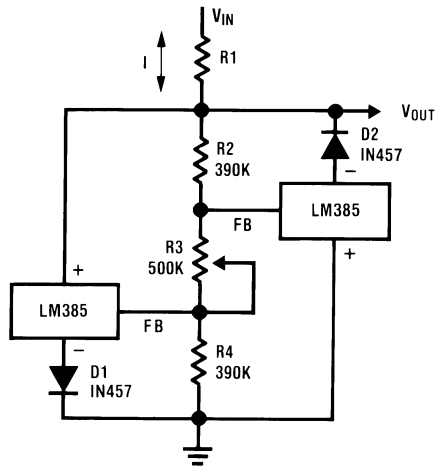


00525034



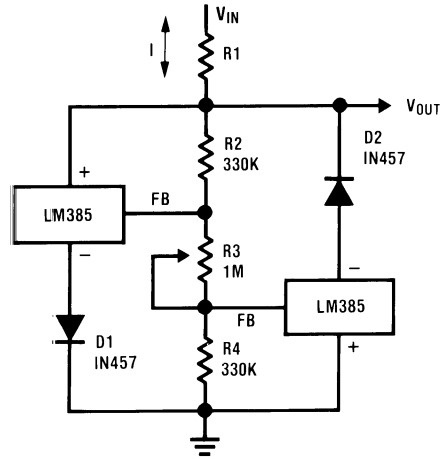
## Typical Applications (Continued)

**Bidirectional Adjustable Clamp**  
±1.8V to ±2.4V



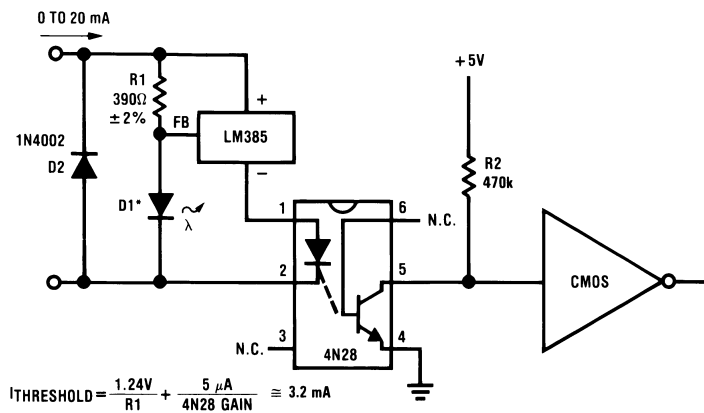
00525035

**Bidirectional Adjustable Clamp**  
±2.4V to ±6V



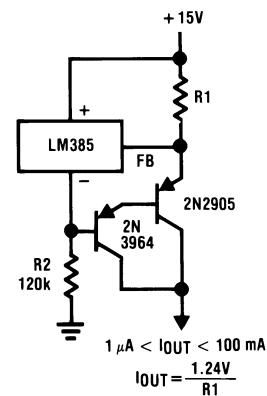
00525036

**Simple Floating Current Detector**



00525037

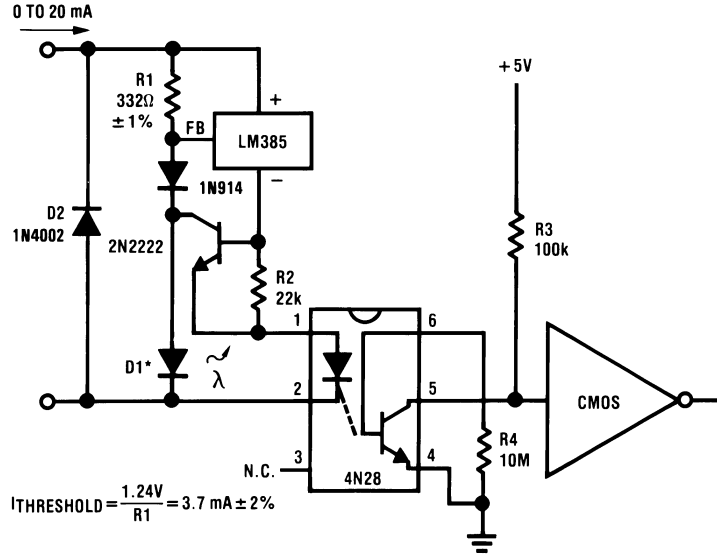
**Current Source**



00525038

## Typical Applications (Continued)

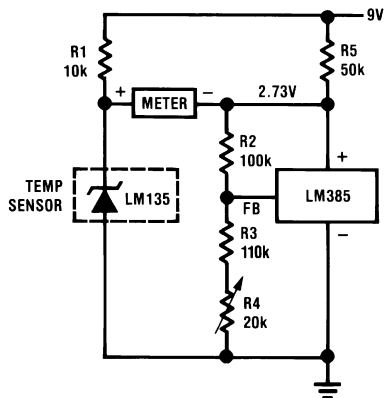
### Precision Floating Current Detector



00525039

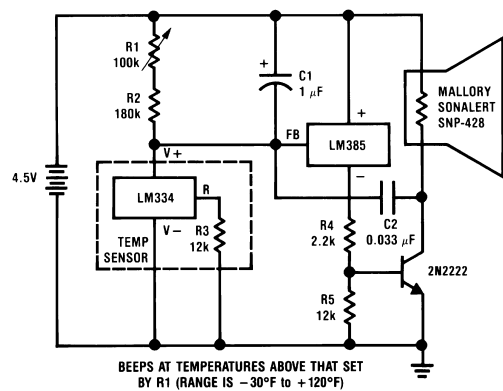
\*D1 can be any LED,  $V_F = 1.5V$  to  $2.2V$  at  $3 \text{ mA}$ . D1 may act as an indicator. D1 will be on if  $I_{THRESHOLD}$  falls below the threshold current, except with  $I=0$ .

### Centigrade Thermometer, 10mV/°C



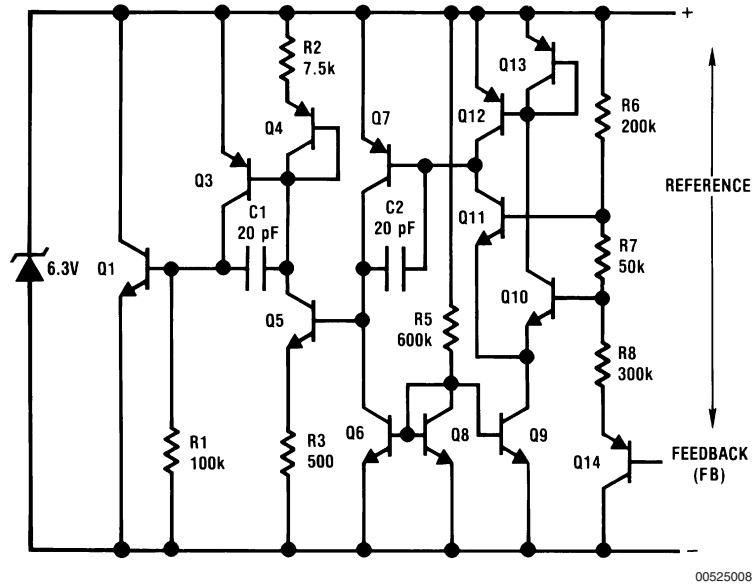
00525011

### Freezer Alarm

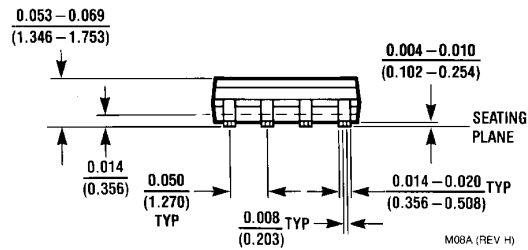
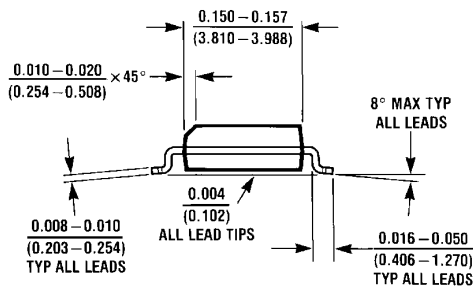
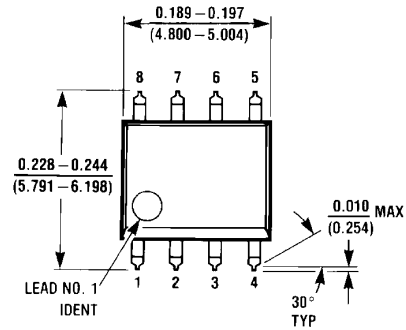


00525012

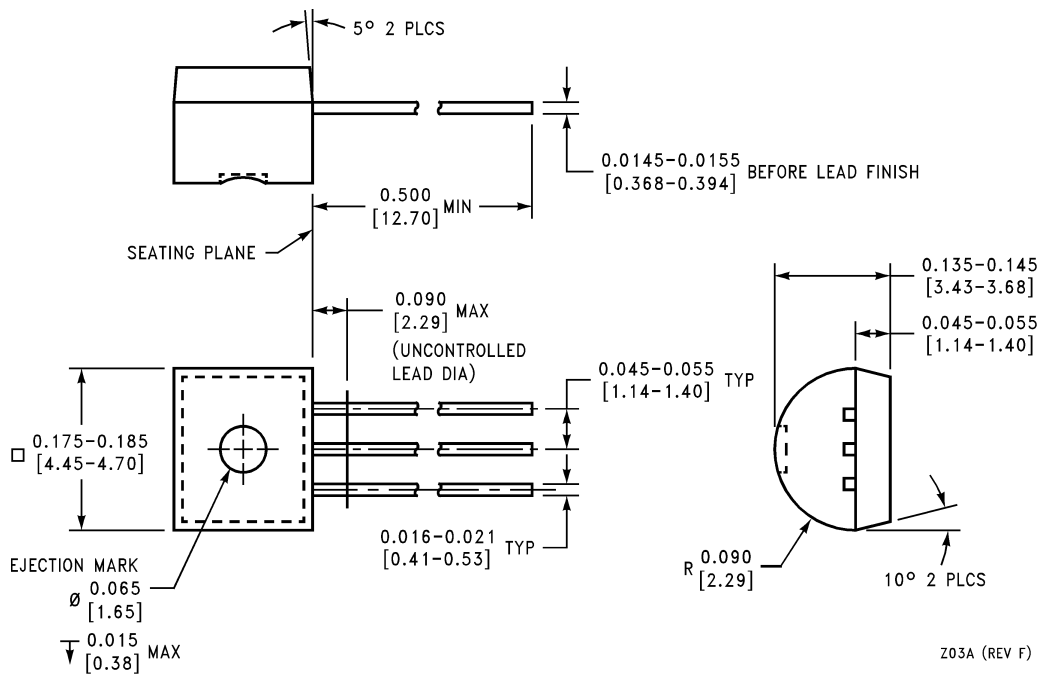
### Schematic Diagram



inches (millimeters) unless otherwise noted (Continued)



SO Package (M)  
NS Package Number M08A



TO-92 Plastic Package (Z)  
NS Package Number Z03A